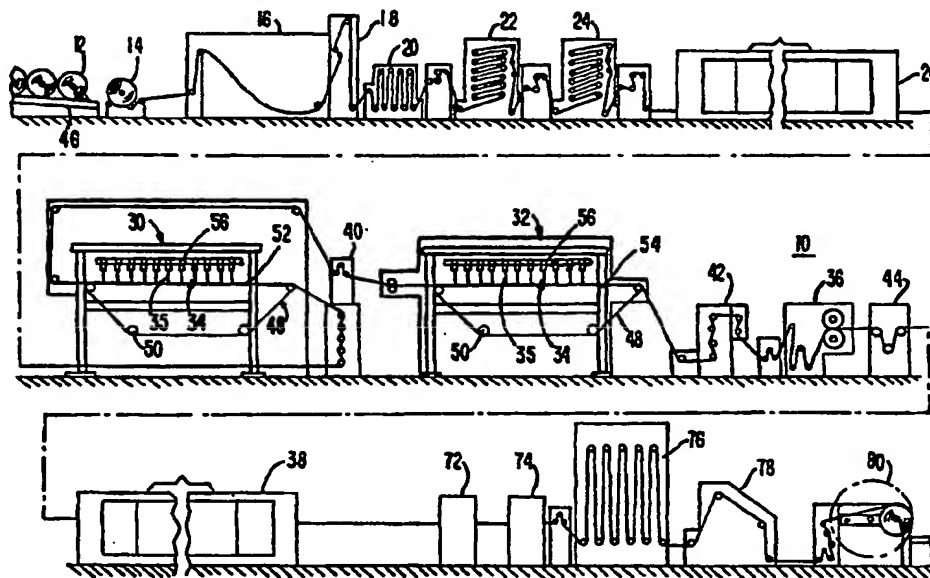


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(21) International Application Number: PCT/US96/10077 (22) International Filing Date: 7 June 1996 (07.06.96) (30) Priority Data: 08/487,261 7 June 1995 (07.06.95) US (71) Applicant: INTERNATIONAL PAPER COMPANY [US/US]; Two Manhattanville Road, Purchase, NY 10577 (US). (72) Inventors: MALANEY, Frank, E.; 6912 Premier Drive, Charlotte, NC 28277 (US). TY, Frederick; 436 High Street, Walpole, MA 02081 (US). STERNLIEB, Herschel; 21 McKeen Street, Brunswick, ME 04011 (US). HENNING, Gregory; 12523 Abbotsbury Court, Charlotte, NC 28277 (US). (74) Agent: OSTRAGER, Glenn, F.; Ostrager, Chong & Flaherty, 300 Park Avenue, New York, NY 10022 (US).		(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i>

(54) Title: FILAMENT CLOTH WITH HYDRAULIC FLUID TREATMENT



(57) Abstract

An hydraulic treatment apparatus (10) and method is provided for finishing and upgrading the quality of filament cloth materials. The fabric (12) is supported on a member (52, 54) and impacted with a uniform, high density jet, fluid curtain (34, 70) under controlled process energies. Low pressure/low energy treatments spread filaments in the fabric to reduce air porosity and provide improved uniformity in material finish. High pressure and energy treatments increase fabric bulk and porosity. Fluid treated fabrics of the invention demonstrate substantial improvement in at least two of uniformity, cover, opacity, increased or decreased bulk, increased or decreased air permeability, abrasion resistance, tensile strength, edge fray, and seam slippage.

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Description

FILAMENT CLOTH WITH HYDRAULIC FLUID TREATMENT

Field of Invention

5 This invention generally relates to a finishing process for improving the uniformity and physical properties of flat, microdenier, conjugate, and textured filament fabrics. More particularly, it is concerned with an hydraulic fluid treatment process which imparts
10 improved uniformity, controlled porosity and improved texture in filament fabrics.

Background Art

 Conventional filament fabrics are composed of two sets of yarns, warp and filling, that is formed by
15 weaving and interlacing the yarns. Filaments within the weave are composed of continuous fibers of indefinite length which are assembled in bundles with or without twist. Various types of filament fabrics are engineered by employing conventional weave constructions, which
20 include plain, twill and satin weaves. Other effects in such woven materials are obtained through use of varying types of yarns.

 Woven filament fabrics are widely used in diverse industries including, protective apparel, marine
25 fabrics, passenger restraint bags for automobiles ("airbags"), computer circuit board composite materials,

printer ribbons, filter materials, window coverings, bedspreads, men's and women's apparel and various other cloths. Filament yarns used in these materials are made of a variety of materials including manufactured fibers such as nylon, polyester, polyethylene, high molecular weight polyethylene, rayon and glass.

For various fabric applications, it is beneficial to provide materials which have uniform textures and low permeabilities. For example, in automobile airbags it is essential that fabrics be engineered to precise permeabilities to provide for controlled gas inflation and deflation. Similarly, in protective apparel for medical and other applications controlled permeabilities are essential to provide adequate barrier properties.

It has been found that conventional weaving techniques do not provide filament fabrics with sufficient uniformity and consistent permeability features. To improve the uniformity and other properties of filament materials it has been necessary to employ various finishing coatings. For example, in filament cloth for airbags, it is common practice to apply resin binders to reduce permeability in the fabric. Such coated materials are not satisfactory because of reduced flexibility, increased weight and long term instability.

As an alternative to coating techniques, the art has recently proposed that filament cloths can be thermally calendared to obtain improved uniformity and

reduced permeability. Thermal calendaring techniques for application to filament materials are disclosed in U.S. Patent Nos. 5,073,418 and 5,010,663, both to Thornton et al., which are directed to materials having specific application in automobile airbags. However, this technique is not entirely satisfactory because calendaring denigrates the tensile and tear properties of the fabric.

Hydroenhancement techniques have been developed for enhancing the surface finish and texture, durability, and other characteristics of woven or knit spun and spun filament yarn fabric. For example, such techniques are described in commonly owned U.S. Patent Nos. 4,967,456 and 5,136,761 of H. Sternlieb et al. The hydroenhancing process generally includes exposing one or both surfaces of a fabric to fluid jet treatment, followed by removal of moisture from the fabric and drying. During hydroenhancement, the high pressure water jets impact upon the spun yarns and cause them to bulk or bloom and the fibers in yarn to become interentangled. Fabrics produced by this hydraulic treatment process have enhanced surface finish and improved characteristics such as cover, abrasion resistance, drape, stability as well as reduced air permeability, wrinkle recovery, seam slippage and edge fray. Hydroenhancing technology is not suitable for 100 percent filament based fabrics because filaments within the fabric do not have free fiber ends which are capable of entanglement.

It is known in the art that hydraulic treatment improves surface smoothness and uniformity of filament fabrics. This art is represented by U.S. Patents 4,707,565, 5,217,796, and 5,281,441 to Kasai et al. which
5 disclose hydraulic treatment of glass filament materials used in electronic circuit boards. Conventional circuit boards include a metal foil mounted onto a multiple layer laminate of filament glass fabric materials impregnated with synthetic resin. Hydraulic processes are employed
10 in Kasai to spread and open filaments in the fabrics to improve resin impregnation. Hydraulic apparatus employed in the Kasai patents employ rotary nozzle mechanisms.

It is believed that the Kasai process is
15 deficient in that it fails to achieve uniform improvement in fabric properties. Moreover, the Kasai process is not satisfactory for engineering filament fabrics to uniform and controlled porosity specifications.

U.S. Patent 5,73,360 to Hiroe et al. discloses
20 a hydraulic fluid treatment process for improving the "smoothness" of continuous filament fabric having application for use in ink ribbons. This teaching is particularly directed to processing of low twist, and high warp density filament fabrics which have ink ribbon
25 application.

Accordingly, it is the broad object of the present invention to provide an hydraulic treatment process and related apparatus for production of woven

filament fabrics which have improved uniformity and physical properties.

A more specific object of the invention is to provide an hydraulic treatment process for improving the
5 texture, bulk and permeability properties of woven filament fabrics.

Another object of the invention is to provide an hydraulic treatment process which can uniformly increase or decrease air porosity of filament fabrics to
10 precise specifications.

A further object of the invention is to provide an hydraulic production line apparatus which is less complex and improved over the prior art.

Disclosure of the Invention

In the present invention, these purposes, as well as others which will be apparent, are achieved generally by providing an apparatus and related method
5 for hydraulic treatment of woven filament fabrics through dynamic fluid action. An hydraulic treatment apparatus is employed in the invention in which the fabric is supported on a member and impacted with a uniform, high density jet, fluid curtain under controlled process
10 energies. According to the invention, energy and pressure process parameters are correlated to fabric porosity in finished fabrics. Low pressure/low energy treatments spread filaments in the fabric to reduce air porosity and provide improved uniformity in material
15 finish. High pressure and energy treatments increase fabric bulk and porosity. Fluid treated fabrics of the invention demonstrate substantial improvement in at least two of uniformity, cover, opacity, increased or decreased bulk, increased or decreased air permeability, abrasion
20 resistance, tensile strength, edge fray, and seam slippage.

According to the preferred method of the invention, the filament fabric is advanced on a process line through (i) a scouring station to clean and remove
25 sizing and dirt from the fabric, (ii) a pre-tentering station to stretch the fabric to a pre-determined excess width to compensate for shrinkage associated with the fluid treatment, (iii) two in-line hydraulic stations for

fluid treatment of top and bottom surfaces of the fabric, and (iv) a post-tentering station to stretch the fabric to a desired output width. Tentering treatments are optional and are preferred for fabrics which have stretch characteristics. Such tentering processing is generally not employed in finishing non-stretchable or limited stretch fabrics.

An apparatus for practicing the invention comprises a continuous line including, scouring, hydraulic treatment, and tentering stations which are adapted for continuous fabric processing. The hydraulic treatment stations preferably include a plurality of cross-directionally ("CD") aligned and spaced manifolds in which are mounted fluid jets. A continuous curtain for the process of the invention is provided by a high density spacing of jet nozzles substantially across each of the manifolds. The fluid jets, which are preferably columnar in configuration, are provided by jet nozzles or orifices which have a diameter of 0.0081 to 0.0229 cm (0.0032 to 0.009 inches), and centre-to-centre spacing of 0.0244 to 0.0635 cm (0.0096 to 0.025 inches). The fluid curtain preferably impacts the fabric with a sufficient energy in the range of 1.1466×10^4 - 22.932×10^6 joule/kg (.002 - 4.0 hp-hr/lb), and preferably 2.8665×10^5 to 9.1728×10^6 joule/kg (0.05 - 1.6 hp-hr/lb). It is preferred to employ jet pressures in the range of 689 to 20,685 kpa (100 to 3000 psi). The line operates at a speed in the range of .0508 to 4.064 m/sec (10 to 800

fpm), and preferably 0.762 to 3.048 m/sec (150 to 600 fpm). At the process energies and line speeds of the invention, the arrangement of densely spaced jets provides a curtain of fluid which yields a uniform fabric
5 finish.

The finishing process of the invention has application for finishing filament cloth materials. Fabrics of the invention may be woven employing conventional weaving techniques of filament yarns
10 including olefinic, inorganic, polyester, polyamide, polyethylene, high molecular weight polyethylene, aramid, cellulosic, lyocell, acetate and acrylic fibers.

Other objects, features and advantages of the present invention will be apparent when the detailed
15 description of the preferred embodiments of the invention are considered in conjunction with the drawings which should be construed in an illustrative and not limiting sense as follows:

Brief Description of the Drawings

20 Fig. 1 is a schematic diagram of the process steps for hydraulic finishing woven filament fabric in accordance with the invention;

Fig. 2 is a side elevational view illustrating a preferred embodiment of a production line for hydraulic
25 finishing of filament materials of the invention;

Fig. 3 is a cross-sectional view of a manifold employed in an hydraulic treatment module of the

invention;

Figs. 4A and B show alternative jet strip orifice configurations which may be used in the manifold structure of Fig. 3;

5 Fig. 5 is a partial isometric view of the manifold of Fig. 3 showing a jet strip structure and columnar fluid curtain employed in the invention;

Fig. 6 is a perspective view of an alternative manifold arrangement of the invention including a fluid
10 curtain formed by overlapping fan jets;

Figs. 7A and B are photomicrographs at 55X magnification of a control and hydraulically processed nylon filament fabric in accordance with Example 3;

Fig. 8 is a graph of air permeability across
15 the fabric width of a control and hydraulically processed nylon fabric of Example 8 showing uniformly controlled porosity obtained in the invention; and

Figs. 9A - D are photomicrographs at 30X magnification of a control and hydraulically processed
20 glass filament fabric at pressures of 200, 300 and 1500 psi in accordance with Example 10, Sample A.

Best Mode Of Carrying Out The Invention

The hydraulic apparatus, related method and products of the invention obtain a controllable uniformity and porosity in woven filament materials by the application of non-compressible fluid under pressure to the fabric which is carried on a support member. The invention applies a continuous curtain of water to conventional filament cloth materials to obtain improved uniformity in yarn spacing and associated "controlled porosity" in the fabric. It should be understood that the principles of the invention have general application to all filament fabric types which have woven components, including woven/nonwoven composite materials.

With reference to the general process steps of the invention as illustrated in Fig. 1, the fabric is first subjected to required pre-treatment processes, which may include washing to remove dirt and sediments, and scouring to remove fabric sizing. To compensate for shrinkage in the fabric associated with subsequent hydraulic processing, the fabric may also be pre-tentered to stretch it to a shrink compensating excess width. The pre-treated fabric is then advanced to an hydraulic treatment station in which the fabric is supported on a member and impacted with a continuous curtain of a non-compressible fluid, such as water. Following hydraulic treatment, the fabric is advanced to a post-treatment station and subjected to any required finishing processing which may include, for example, post tentering

to obtain a fabric of the desired output width, and
padder application of finishing treatments.

In order to obtain "controlled porosities" in
fabrics of the invention it is necessary to impact the
5 fabric with a uniform, high density jet, fluid curtain
under controlled process energies. The porosity in
finished fabrics correlates to energy and pressure
process parameters. To obtain demonstrable improvements
in fabric properties the fluid curtain should comprise a
10 dense and uniform array of jets which impact the entire
width of the fabric. The fabric must also be impacted
with a cumulative process energy in the range of 1.1466×10^6 - 22.932×10^6 joule/kg (.002 - 4.0 hp-hr/lb) and
preferably 2.8665×10^5 to 9.1728×10^6 joule/kg (0.05 -
15 1.6 hp-hr/lb), and jet pressures in the range of 689 to
20,685 kpa (100 to 3000 psi) for effective finishing
treatment in the invention.

Referring now to Fig. 2, there is illustrated
one preferred form of hydraulic finishing apparatus line
20 of the invention, generally designated 10. The
production line includes pre-treatment stations for
processing the fabric 12 including, unwind station 14,
scray 16, edge guide 18, saturator 20, washer or scouring
stations 22, 24, and pre-tenter station 26. Following
25 pre-treatment processing the fabric is advanced through
hydraulic treatment modules 30, 32 which impact the
fabric, preferably on both sides, with a fluid curtain
34. Following hydraulic processing the fabric is

advanced to post-treatment stations which may include a
padder 36 and tenter frame dryer 38. Further stations
which are preferred for use on the line include weft
straighteners 40, 42 which are respectively positioned on
5 the line between modules 30, 32 and before padder station
36. An optical inspection station (not shown) to monitor
the fabric for defects and contaminants may be provided
between the scray 16 and saturator 20. A vacuum
extractor station 44 may be positioned following the
10 padder station 36. It will be appreciated by those
skilled in the art that additional edge guide stations
may be employed in the line to center the fabric with
centerline of the apparatus line.

Turning first to the pre-treatment stations of
15 the line. Fabric rolls are received in unwind station 14
where the fabric rolls are placed, in succession, on roll
feed table 46. In order to provide a continuous
processing line capability, the fabric is advanced to a
scray apparatus 16 in which in the beginning and end
20 sections of successive rolls are joined together by
conventional sewing techniques.

From the scray 16, the fabric is advanced to
saturator 20 and scouring or washers 22, 24 to clean the
fabric prior to hydraulic treatment and, if required to
25 remove sizing and tint which are generally used in the
weaving of fabrics. The saturator and washing apparatus
are preferably provided with regulated temperature
controls and scouring water temperatures of up to 195

degrees Fahrenheit.

Following the scouring treatment, the fabric is pre-tentered (stretched) at pre-tenter station 26 to a predetermined width in excess of a desired finished width of the fabric. The pre-tentering width is selected so that the expected shrinkage caused by the hydraulic treatment process reduces the width of the finished fabric to slightly less than the desired finished width. The post-tenter or tenter frame dryer 38 is used to post-tenter the fabric after hydraulic processing only by a slight amount to the exact desired finished width.

The preferred process line of the invention is provided with two in-line hydraulic treatment modules 30, 32. As shown in Fig. 2, the fabric is first fluid treated on one side in module 30 and then, advanced to module 32 for treatment of its reverse side. Each module 30, 32 includes an endless conveyor 48 driven by rollers 50 and tensioning guide mechanisms (not shown) which advance the fabric in a machine direction on the line. The conveyor 48 in each module presents a generally planar support member, respectively designated 52, 54 in modules 30, 32, for the fabric in the hydraulic treatment zone of the module.

The support members 52, 54 preferably have a substantially flat configuration, and may be solid or include fluid pervious open areas (not shown). The preferred support members 52, 54 for use in the invention

are a plain mesh weave screen. For example, a conventional mesh stainless steel or plain weave screen formed of polyester warp and shute round filament. The fabric is supported in contact with screen while open areas drain away water applied to the fabric, as described further below. In the preferred embodiments, the open areas occupy approximately 12 to 40 percent of the screen.

Conventional filament fabrics have reed markings and other irregularities associated with their production. The invention overcomes these defects in a two stage hydraulic finishing process which stabilizes the fabric by uniformly spacing filament yarns in the fabric weave. Further advantage is obtained by use of support members 52, 54 which include fine mesh screens which have a variety of contoured weave patterns which may include, for example a twill weave.

Each module 30, 32 includes an arrangement of parallel and spaced manifolds 56 oriented in a cross-direction ("CD") relative to movement of the fabric 12. The manifolds which are spaced approximately 20.3 cm (8 inches) apart each include a plurality of closely aligned and spaced columnar jet orifices 58 (shown in Fig. 4A) which are spaced approximately 1.27 to 2.45 cms (0.5 to 1 inches) from the support members 52, 54. A preferred manifold structure employs a jet strip 60 which is provided with precisely calibrated jet orifices which define the jet array.

Fig. 3 shows a cross-section of a preferred manifold structure for use in the invention. High pressure is directed through the main plenum 62 to distribution holes 64. As best shown in Fig. 5, the jet strips 60 are mounted in the manifold to provide a dynamic fluid source for the jet strips. The jet orifices preferably have diameters and center-to-center spacings in the range of 0.0081 to 0.0229 cm (0.0032 to 0.009 inches), and centre-to-centre spacing of 0.0244 to 0.0635 cm (0.0096 to 0.025 inches), respectively, and are designed to impact the fabric with fluid pressures in the range of 689 to 20,685 kpa (100 to 3000 psi).

Fig. 4A shows a preferred jet strip 60 which includes a dense linear array of jet orifices 58. It is believed that advantage is obtained by employing a uniform and extremely dense array of jets. A preferred density for the linear jet array would be in the approximate range of 61 to 104 orifices per inch. Fig. 4B shows an alternative jet strip 66 which includes staggered linear arrays of jet orifices 68. This staggered arrangement obtains an increased jet orifice density of approximately 122 to 208 orifices per inch.

Energy input to the fabric is cumulative along the line and preferably set at approximately the same level in modules 30, 32 to impart uniform hydraulic treatment to the fabric. Within each module advantage may be obtained by ramping or varying the energy levels

from manifold to manifold. According to the invention, the fluid curtain 34 is uniform and continuous in the cross direction of the line. As will more fully described hereinafter, the fluid curtain preferably
5 comprises a dense array of columnar fluid jets 35. Energy specifications for the fluid curtains are selected to correlate with desired end physical properties in finished fabric.

In the hydraulic modules, the fabric is
10 preferably impacted with uniform fluid on both top and bottom sides. Energy requirements for effective fabric finish vary as a function fabric type, composition, weave, and weight. Accordingly, it is necessary to employ a cumulative process energy which is sufficient
15 for a select fabric work piece to improve the uniformity of yarn spacing within the fabric. Demonstrable improvements in physical properties are obtained in the invention within the energy range of $1.1466 \times 10^4 - 22.932 \times 10^6$ joule/kg (.002 - 4.0 hp-hr/lb), and preferably
20 2.8665×10^5 to 9.1728×10^6 joule/kg (0.05 - 1.6 hp-hr/lb).

A preferred schematic of the fluid curtain is best shown in Fig. 5 wherein columnar jets 35 are shown in a dense array positioned in the cross-direction of
25 production line 10. The columnar jets in the curtain have a generally perpendicular orientation to a support member. Fig. 6 shows an alternative fluid curtain 70

including divergent or angled fluid jets 73. This arrangement provides a tenting effect in the hydraulic process to stabilize the fabric matrix.

Following hydraulic treatment the fabric may be
5 advanced for post-treatment through the weft straightener
42, padder 36, vacuum extractor 44, and tenter frame
dryer station 38. For example, at padder station 36
conventional resins and finishing treatments may be
applied to the fabric 12. A feature of the invention is
10 the use of a combination of pre- and post-treatment
tenter frame processing to control shrinkage associated
with the hydraulic treatment.

Following tenter drying, the fabric 12 is
advanced to inspection stations which may include, a weft
15 detector 72 to sense fabric straightness, moisture
detectors (not shown) and optical equipment 74 to monitor
the fabric for possible defects. Fig. 2 also shows a
fabric accumulator 76, operator inspection station 78 and
fabric wind-up station 80.

20 Hydraulic processing according to the invention
may be practiced on woven filament yarn fabrics of
convention weaves. Filament yarns suitable for use in
the invention fabrics may be selected from the material
groups comprising olefinic, inorganic, polyester,
25 polyethylene, high molecular weight polyethylene,
polyamide, aramid, cellulosic, lyocell, acetate and
acrylic fibers.

It will be recognized that advantage can be obtained in the invention by specification of filament yarn types for use in the invention fabrics.

Conventional filament yarns are composed of continuous
5 filaments assembled with or without twist. For example, flat, microdenier, and conjugate yarn constructed fabrics, respectively, have applications which include use in protective apparel, marine fabrics, passenger restraint bags for automobiles, computer circuit board
10 composite materials, filtration materials, window coverings, bedspreads, printer ribbons, men's and women's apparel, and various other cloths. Fabrics which include yarns of low twist are generally found to more demonstrably respond to hydraulic processing.

15 Prior art hydraulic techniques having application to upgrade the quality of spun yarn fabrics are disclosed in commonly owned U.S. Patent Nos. 4,967,456 and 5,136,761 of H. Sternlieb et al., which are incorporated herein by reference. According to the
20 teachings of this art, high pressure water jets impact upon the spun yarns and cause them to bulk or bloom and interentangle fiber ends in the spun yarn.

Filament fabrics do not have fiber ends which entangle in response to hydraulic treatment. However, in
25 the present invention it is found that hydraulic entanglement effects can be simulated by using fabrics which include texturized yarns. Such yarns have loops, coils or folded portions which interentangle in response

to hydraulic processing. Advantageously, hydraulic processing of texturized filament content fabrics yields substantial improvements in fabric tensile characteristics and cover.

5 An advance in the present invention resides in providing an hydraulic treatment process which permits engineering of filament fabrics to exacting or "controlled porosity" specifications. The invention correlates fabric porosity characteristics to energy and
10 pressure process parameters. Low pressure/low energy treatments spread filaments in the fabric to reduce air porosity and provide improved uniformity in material finish. High pressure and energy treatments increase fabric bulk and porosity. It is found that various
15 physical properties of filament fabrics are obtained as an adjunct to stabilizing the fabric weave. In particular, fluid treated fabrics of the invention demonstrate substantial improvement in at least two of uniformity, cover, opacity, increased or decreased bulk,
20 increased or decreased air permeability, abrasion resistance, tensile strength, edge fray, and seam slippage.

 As representative of the scope of the invention, Examples are set forth below to illustrate
25 pre-selected improvements in the physical properties in fabric work pieces. For the Examples, a prototype line was employed which simulated the two stage hydraulic modules of the invention. Prior to hydraulic processing

fabrics of the Examples were scoured to clean and remove sizing from the fabric. Following hydraulic treatment, the fabrics were processed in a heat set tenter to impart a uniform width to the fabric. It will be recognized
5 that further advantage would be obtained in the Examples with the addition, for fabrics having stretch characteristics, of pre-tenter processing of the invention.

Fabrics processed in the Examples exhibited
10 demonstrable improvements in physical properties including, characteristics such as cover, permeability, abrasion resistance, tensile strength, stability, and reduction in seam slippage, and edge fray.

As in the Fig. 2 line, two hydraulic modules
15 were employed for treatment of top and bottom sides of the fabric. Within each module manifolds 56 were spaced approximately 20.3 cm (8 inches) apart and provided with densely packed columnar jets. Specifications of the fluid curtain were varied in the Examples to obtain
20 specified energy levels and illustrate the range of properties which can be altered in the invention process.

Tables I-X set forth data for fabrics hydraulically treated in accordance with invention on the test process line. Standard testing procedures of The
25 American Society for Testing and Materials (ASTM) were employed to test control and processed characteristics of fabrics.

Example 1

Reduction in air permeability, increased bulk and increased warp tensile.

A 100% cellulose acetate filament fabric having the following specifications was processed in accordance with the invention: 115 denier warp yarns and 150 denier weft yarns in a 120 x 68 plain weave construction and approximate weight of 3.03 ounces/yd².

The fabric was processed on a 100 x 94, 2 x 1 semi-twill weave stainless steel screen having a 28% open area. Manifolds used in the Example were provided with orifice strips having 0.005 inch diameter holes at a frequency of 61 holes/inch. Manifold pressure was set at 1,000 psi and line speed at 41 feet per minute. The fabric sample was passed under two manifold positions on each of its sides. A cumulative energy level of 0.5 HP hr/lb of fabric yielded the following results:

TABLE I

20

	Air Perm (cfm/ft ²)	Bulk (Mils)	Warp Tensile (Lbs.)	Percent Fraying
Control (Untreated)	38.8	7.7	39.4	33.8
Processed	17.1	8.2	44.6	9.0

Example 2

Increases in air permeability, increased bulk and improved abrasion resistance.

A 100 percent texturized polyester fabric of the type used in outdoor upholstery cloth was processed in this Example to illustrate improvements in fabric cover that can be obtained in the invention. Fabric specifications include: 2-ply 150/34 denier warp and fill yarns, 58 x 46 construction and approximate weight of 4.6 oz./yd².

The sample fabric was passed under 6 manifold positions on each side of the fabric, and processed on a 100 x 94, 2 x 1 semi-twill weave stainless steel screen. The manifolds contained orifice strips having 0.005 inch diameter holes at a frequency of 61 holes/inch. The manifold pressure is 1500 psi and line speed is 142 feet per minute. A cumulative energy level of 0.5 hp-hr./lb of fabric produced the following results:

TABLE II

	Air Perm (cfm/ft ²)	Abrasion To Hole Cycles	Bulk (mils)
Control (Untreated)	11.5	1545	12.8
Processed	16.2	2536	15.5

Example 3

Pore size reduction and uniformity improvement.

Various nylon based fabrics have application for use in printer ribbon materials. This Example illustrates use of hydraulic treatment to obtain "controlled" and "uniform" porosity fabric with improved ink holding specifications.

A 100 percent nylon filament cloth was provided with a 170 x 110 construction and weight of 2.1 oz/yd². The fabric is passed under three manifold positions on each side supported on a 36 x 28 plastic screen. The manifold is provided with orifice strips that have .0032 inch holes at a frequency of 104 holes/inch. A treatment energy level of 0.5 hp-hr./lb. of fabric at 1000 PSI and line speed of 68 ft/min yields the following fabric pore results:

TABLE III

	Min. Pore (Microns)	Max. Pore (Microns)	Avg. Pore (Microns)
Control (Untreated)	7.85	56.2	20.49
Processed	6.09	20.7	9.38

Example 4

Improvements in yarn slippage reduction in bulk and air permeability.

A 100 percent texturized polyester upholstery fabric was provided with a 19 x 17 construction and weight of 6.9 oz/yd². The fabric is passed under six manifold positions on each side supported on a 100 x 94 plain weave stainless steel screen. The manifold is provided with orifice strips that have .005 inch holes at a frequency of 61 holes/inch. A treatment energy level of 0.5 hp-hr./lb. of fabric at 1,000 PSI and line speed of 96 feet per minute yields the following results:

TABLE IV

	Yarn Slippage (Lbs.)		Bulk (Mils)	Air Perm (Cfm/Ft ²)
	Warp	Fill		
Control (Untreated)	65.5	60.3	59.2	333
Processed	150.2	158.2	50.1	97

Example 5

Increased air permeability, tensile, elongation and bulk with reduced pore size.

A 100% filament fabric having application for
5 use in protective apparel was provided with the following specifications: 153 x 75 construction and weight of 3.7 oz/yd²; warp yarn of 100 denier/50 texturized yarn and fill of 150 denier flat filament.

The fabric is passed under four manifold
10 positions on each side supported on a 100 x 94 plain weave stainless steel screen. Manifolds are provided with orifice strips that have .005 inch holes at a frequency of 61 holes/inch. Table V sets forth results obtained at a treatment process energy of .5 hp-hr./lb.,
15 pressure of 700 psi and line speed of 41 fpm.

26

TABLE V

	Pore Size (Micron)			Bulk Mils	Air Perm (CFM/Ft ²)	Tensile (lbs.)		Elongation %	
	Max.	Min.	Avg.			Warp	Weft	Warp	Weft
Control (Untreated)	112.2	4.7	8.4	9.4	3.2	139.4	40.4	31.7	23.3
Processed	62.	3.8	5.7	12.3	6.7	151.9	53.4	50.7	28.4

TABLE VI

	Energy Hp-hr/lb	Bulk Mils	Air Perm CFM/Ft ²	Tensile (lbs)		Elongation %	
				Warp	Weft	Warp	Weft
Control (Untreated)	0	11.6	1.7	306	258	30.5	32.6
Processed 1.	0.2	15.5	7.6	361	335	37.6	36.9
Processed 2.	0.6	18.8	10.4	353	305	38.9	39.9
Processed 3.	1.2	20.9	14.1	371	329	42.8	43.8

Example 6

Controlled, increased air permeability, bulk, tensile and percent elongation.

A nylon filament fabric constructed of flat
5 filaments having a 47 x 45 construction and weight of 5.4
oz/yd² is processed in this Example employing a fluid
curtain having a ramped energy distribution. Hydraulic
treatment specifications include manifolds having .005
inch diameter holes with a density of 61 holes per inch.,
10 a 100 x 94 stainless steel screen, fluid pressure of 1500
psi and line speed of 52 fpm. A cumulative treatment
energy of 2.0 Hp-hr/lb was applied to the fabric at a
pressure of 1500 psi. The fabric was treated by one
manifold on each side for 0.2 Hp-hr/lb, three manifolds
15 per side for 0.6 HP-hr/lb, and six manifolds per side for
1.2 Hp-hr/lb. Table VI shows data for changes in
physical properties of the fabric at each energy level of
the process.

Example 7

Control air permeability, improved fabric uniformity, and increased seam strength.

Various nylon based fabrics have application in
5 automobile restraint systems. This Example illustrates
use of hydraulic treatment to obtain "controlled" and
uniform porosity fabric specifications. Fabrics were
processed employing the hydraulic treatment parameters of
Example 4. Table VII sets forth test results for control
10 and processed samples of nylon fabrics of varying deniers
and constructions.

This Example also demonstrates that the
invention yields substantial improvement in yarn slippage
properties. With reference to Table VII, Sample 3 it
15 will be seen that yarn slippage in the Control and
Processed fabrics improved from 77 x 67 lbs. to 389 x 404
lbs.

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TABLE VII

SAMPLE ID	Ends/in (EPI)	Picks/in (PPI)	WT (oz/sq yd)	THICKNESS (mils)	AIR PERM (cfm/sq ft)	GRAB STR warp (lbs)	GRAB STR fill (lbs)	ELONG warp (%)	ELONG fill (%)	TEAR STR warp (lbs)	TEAR STR fill (lbs)
Sample 1: 48 x 54 420 denier nylon [U4453]											
Control	48.3	54.2	6.02	13	0.44	433	497	39.3	31.2	43.7	44.2
Processed	55.6	60.1	7.63	17	2.1	478	534	51.3	52.7	32.8	32.8
Sample 2: 60 x 60 315 denier nylon [U4479]											
Control	60.9	61.4	5.42	12	0.92	450	462	39	28.9	29.8	31
Processed	66.2	66.2	6.21	15	2.35	476	486	49.2	39	21.9	21.4
Sample 3: 32 x 32 ripstop 840 denier nylon [S/28297]*											
Control			7.7	20.1	3.88	510	557	34.7	37.5		
Processed			8.1	30.3	9.31	521	504	32.8	44.9		
Sample 4: 41 x 41 630 denier nylon [S/28274]											
Control	39.5	41.7	7.04	16	1.74	542	602	35.9	30.8	53.2	51.4
Processed	44.6	43.1	8.22	18	6.1	612	608	42.5	38.2	39.1	38.3

* Additional Data: Yarn Slippage

Before Treatment: 77 x 67 lbs
 After Treatment : 389 x 404 lbs

Example 8**Uniform Air Permeability Across Fabric.**

This Example provides a further illustration of uniformity in permeability that may be obtained in the finishing of filament fabrics in the invention process. A control nylon filament fabric having a 52 x 52 construction and weight of approximately 6.21 oz/yd² was found to have air permeability which varied across its width, center to outer edges, from approximately 1 to 1.5 cfm/ft². Hydraulic treatment employing the process parameters of Example 4 yielded a uniform permeability across the fabric of approximately 2 cfm/ft². This result is illustrated in Fig. 8 which is a graph of air permeability of control and processed fabric as a function of position across the fabric. Table VIII sets forth further physical property data for the control and processed nylon fabric.

Example 9**Increased and Decreased Air Permeability.**

This Example demonstrates the relationship between process energy and resulting air permeability in finished fabrics. Nylon fabrics having filaments of various deniers were processed at differing energy levels. In general, it was found that increases in cumulative energy applied to the fabric correlated with increased air permeability. Fabrics processed at lower energy levels exhibited decreased air permeabilities.

Table IX sets forth process condition and physical property data for samples of 420, 630 and 840 denier control and processed nylon fabrics.

TABLE VIII

5

	Fabric Sample	Control	Treated	Change
	Count	52 x 52	58 x 57	
10	Weight (ozpsy) Standard Deviation	6.21 0.01	7.58 0.05	22.15%
	Thickness (mils) Standard Deviation	12.6 0.11	21.0 0.62	66.40%
	Air Perm (cfm/sq.ft) Standard Deviation	1.10 0.27	2.09 0.08	90.00%
15	Warp Grab Tensile (lbs) Standard Deviation	524.30 13.17	538.00 7.24	2.61%
	Weft Grab Tensile (lbs) Standard Deviation	516.92 21.10	546.10 7.58	5.64%
20	Warp Grab Elong. (%) Standard Deviation	42.13 1.45	57.60 1.67	36.72%
	Weft Grab Elong. (%) Standard Deviation	40.27 1.46	56.00 1.25	39.06%
25	Warp Tongue Tears (lbs) Standard Deviation	33.64 0.85	26.76 1.42	-20.45%
	Weft Tongue Tears (lbs) Standard Deviation	34.74 0.98	27.46 1.95	-20.96%

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TABLE IX

SAMPLE ID	Energy (Hp-r/lb)	WT (oz/sq yd)	BULK (mils)	AIR PERM (cfm/sq ft)	PROCESS CONDITIONS (100 X 94 Stainless Steel Screen)			
					Press (PSI)	Speed (FPM)	Orifice # / Size (IN)	PASS SIDE
Sample 1: 420 denier nylon								
Control	--	5.6	12.5	5.0				
Increased Air Permeability	.06	6.0	15.0	7.9	1000	50	61/.005	1 2
Decreased Air Permeability	.008	5.8	13.0	3.8	500	100	104/.0032	1 2
Sample 2: 630 denier nylon								
Control	--	7.0	14.5	2.1				
Increased Air Permeability	.04	7.8	19.0	3.7	1000	50	61/.005	1 2
Decreased Air Permeability	.006	7.5	17.0	1.4	500	100	104/.0032	1 2
Sample 3: 840 denier nylon								
Control	--	7.4	16.9	6.4				
Increased Air Permeability	.04	8.0	21.4	7.8	1000	50	61/.005	1 2
Decreased Air Permeability	.006	7.8	19.4	4.9	500	100	104/.0032	1 2

Example 10Hydraulic Treatment of Glass Filament Fabrics

Hydraulic processing in this Example is employed to engineer smooth, low permeability, glass
5 filament fabrics for use in manufacture of printed circuit boards.

It is known to employ resin coated woven filament fabrics in manufacture of printed circuit boards. Conventional glass filament fabrics comprise a
10 matrix of warp and weft woven filament bundles. (Warp and weft filament bundles are formed by binding or twisting a plurality of monofilaments to form filament yarn.) To obtain smooth surfaces which are required for the printing of circuits, glass fabrics are fabricated
15 from fine yarns in tight constructions.

Hydraulic finishing treatment of this invention permits use of less expensive coarse and open weave filament fabric constructions in the manufacture of filament fabric. Most surprisingly, it was found that
20 "low pressure" hydraulic treatment "spreads" and opens filaments in the fabric to provide an open weave fabric having improved smoothness.

To demonstrate the correlation between pressure treatment, fabric smoothness and permeability, glass
25 filament fabrics were processed at pressures ranging from 200 to 1500 psi. Hydraulic treatment specifications: manifolds having .005 inch diameter holes with a density of 61 holes per inch., and a 100 x 94 stainless steel

support screen. Fabrics were processed under three manifolds on both sides. Table X set forth test results for 87 and 167 gm/yd² fabrics:

TABLE X

	<u>Weight (gm/yd²)</u>	<u>Thickness (Mils)</u>
5	<u>Sample A</u>	
	Control	87.08
	200 psi	82.47
	300 psi	87.08
10	1500 psi	86.00
	<u>Sample B</u>	
	Control	166.95
	200 psi	161.13
15	300 psi	157.23
	400 psi	156.37
	1500 psi	171.61

Figs. 9A - D show photomicrographs at a 30X magnification of control and the hydraulically processed Sample A fabrics. Similar results were obtained for the heavy weight Sample B fabric. It will be seen that hydraulic treatment evenly spreads and flattens the

filament yarn fabric to provide a smooth finish. Optimal results are obtained at the lowest 200 psi treatment. As an adjunct to improved smoothness, the finishing process also obtains reduced permeability in the fabric. At a
5 200 psi treatment, it was found fabric permeability was uniformly reduced from 62 to 1.5 cfm/ft². High pressure treatments in the approximate range of 400 psi and higher caused breakage in monofilaments in the yarn which is disadvantageous for circuit board fabric applications.

10 In the foregoing Examples, the hydraulic treatment process of the invention is shown to yield improved uniformity in fabric weave. More particularly, it is shown that the invention process stabilizes the fabric matrix and obtains improvements in fabric
15 properties including, cover, opacity, increased or decreased bulk, increased or decreased air permeability, abrasion resistance, tensile strength, edge fray, and seam slippage.

Further, advantageous fabric features are
20 obtained in particular material applications of the invention process. For example, it has been found that hydraulic treatment of texturized fabrics yields substantial improvements in seam strength and abrasion resistance. The improvement in seam strength is obtained
25 as a result of entanglement of coil or crimped portions of warp and filling yarn in the fabric. The fabric abrasion resistance improves because the hydraulic treatment drives any free filament lengths on the surface

of the yarn, i.e., filament bundles, into the yarn body.

Hydraulic processing according to the invention also obtains a texturizing effect in filament fabrics.

It will be recognized that this texturizing feature
5 presents a substantial advantage as compared to
conventional techniques in which individual yarns are
processed prior to weaving. Finally, as a further
feature, it is found that the invention process
effectively reduces the luster of filament fabrics such
10 as cellulose acetate.

Thus, the invention provides a method and
apparatus for finishing filament materials by application
of a continuous non-compressible fluid curtain against
support screens. A wide range of fabric properties can
15 be upgraded or obtained for desired fabric applications.
The hydraulic treatment technique of the invention
upgrades the fabric by uniformly spacing filament yarn in
the fabric. Additionally, the production line of the
invention provides an in-line capability to coat or
20 impregnate processed fabrics with various conventional
resins, softeners, and repellants for specified end uses.
Further pre-and post treatment processes may also be
employed, for example, soft and caustic scouring to
remove oil, sizing and dirt. Pre-tentering and post-heat
25 setting tentering may also be used to stretch, shrink and
heat set the fabric.

Other modes of hydroprocess treatment may be
devised in accordance with principles of the invention.

Thus, although the invention employs two hydraulic modules in the process line, additional modules are within the scope of the invention. Advantage would also be obtained by provision of a pre-treatment hydraulic module for opening fabric yarns prior to pre-tentering. See Fig. 2. Similarly, although, columnar jets are preferred for use in the invention fluid curtain, other jet types are within the scope of the invention. For example, advantage may be obtained by use of a fluid curtain which includes divergent or fan jets. Hydraulic fluid treatment systems which include fan jets are described in commonly owned U.S. Patent Nos. 4,960,630 and 4,995,151 which are incorporated herein by reference.

Divergent jet systems are advantageous insofar as angled fluid streams, which overlap, effect a uniform processing of the fabric. Where divergent jets are employed it is preferred that the jets have an angle of divergence of approximately 2-45 degrees and spacing from the support screen of 2.54 to 25.4 cm (1 to 10 inches) to define an overlapping jet array. Experimentation has shown that a divergence angle of about 18 degrees yields an optimum fan shape and an even curtain of water pressure.

Similarly, although the preferred line employs support members or screens which have a generally planar configuration, it will be appreciated that contoured support members and/or drum support modules may be used in the invention.

Other variations of structures, materials, products and processes may of course be devised. All such variations, additions, and modifications are nevertheless considered to be within the spirit and scope
5 of the present invention, as defined in the claims appended hereto.

Claims

1. A method for finishing textile fabrics including warp and filling filament yarns formed by interlacing of the yarns, the method comprising the steps
5 of:

supporting the fabric on a support member, and uniformly and continuously impacting at least one side of the fabric with a continuous curtain of fluid which impacts the fabric with a sufficient energy to
10 improve the uniformity of the yarn spacing within the fabric.

2. A method according to claim 1, wherein the continuous curtain of fluid impacts the fabric with an energy in the range of 1.1×10^4 - 22.9×10^6 joule/kg
15 (.002 - 4.0 hp-hr/lb).

3. A method according to claim 2, wherein the uniform and continuous curtain of fluid is provided by an array of densely spaced liquid jets which emanate from jet orifices.

20 4. A method according to claim 3, wherein the conveying speed is from .0508 to 4.064 m/sec (10 to 800 fpm), and jet pressure is from 689 to 20,685 kpa (100 to 3000 psi).

5. A method according to claim 3, wherein the jets
25 are columnar, the jet orifices have a diameter of .0081 to .0229 cm (.0032 to .009 inches), and centre-to-centre spacing of .0244 to .0635 cm (0.0096 to 0.025 inches).

6. A method according to claim 3, wherein the jets eject divergent, fan sprays having an angle of divergence so as to provide overlapping jets of liquid.

7. A method according to claim 6, wherein the
5 nozzles have an angle of divergence of 2 to 45 degrees.

8. A method according to claim 6, wherein the nozzles are disposed about 2.54 to 25.4 cm (1 to 10 inches) above the conveyor.

9. A method according to claim 8, wherein the
10 nozzles have an angle of divergence of 18 degrees.

10. A method according to claim 1, wherein the support member is liquid pervious and includes open areas and has a fine mesh pattern which permits fluid passage without imparting a patterned effect to the fabric.

11. A method according to any one of claims 1 to 6
15 which comprises the further step of pre-tentering the fabric to stretch it to a predetermined excess width.

12. A method according to claim 11, comprising the further step of scouring the fabric prior to the pre-
20 tentering step to clean and remove sizing from the fabric.

13. A method according to claim 11, wherein the fluid treatment step shrinks the fabric a specified width correlating to energy treatment, and the pre-tentering
25 excess width is selected so that the fabric shrinks to a width slightly less than a desired finished width for output fabric.

14. A method according to claim 13, further comprising the step of post-tentering the fabric after the fluid treatment to a desired output width.

15. A uniformly finished woven fabric which
5 comprises: filament yarns which are interlaced at cross-over points to define interstitial open areas, the fabric being made by supporting the fabric on a support member and impacting the fabric with a uniform and continuous fluid curtain, wherein said fluid treatment improves the
10 uniformity of the yarn spacing within the fabric.

16. A uniformly finished woven fabric according to claim 15, wherein the finished fabric demonstrates a substantial improvement in at least two of uniformity, cover, opacity, increased or decreased bulk, increased or
15 decreased air permeability, abrasion resistance, tensile strength, edge fray, and seam slippage.

17. A uniformly finished woven fabric according to claim 15 or claim 16, wherein the continuous curtain of fluid impacts the fabric with an energy in the range of
20 $1.1 \times 10^4 - 22.9 \times 10^6$ joule/kg (.002 - 4.0 hp-hr/lb).

18. A uniformly finished woven fabric as claimed in any one of claims 15 to 17, wherein the fabric includes texturized filament yarn.

19. A uniformly finished woven fabric as claimed in
25 any one of claims 15 to 17, wherein the fabric includes flat filament yarn.

20. A uniformly finished woven fabric as claimed in any one of claims 15 to 17, wherein the fabric includes

texturized warp and fill yarns, and said yarns are fluid entangled in said interstitial open areas by said fluid treatment.

21. A uniformly finished woven fabric as claimed in
5 any one of claims 15 to 17, wherein the fabric includes glass filament yarn.

22. A uniformly finished woven fabric as claimed in
any one of claims 15 to 17, wherein the yarn is composed
of cellulose acetate and the fluid treatment reduces the
10 luster of the fabric.

23. A uniformly finished woven fabric as claimed in
any one of claims 15 to 17, wherein the fabric is made of
filament yarns selected the material groups comprising
olefinic, inorganic, polyester, polyethylene, high
15 molecular weight polyethylene, polyamide, aramid,
cellulosic, lyocell, acetate and acrylic fibers.

24. A uniformly finished woven fabric as claimed in
any one of claims 15 to 17, wherein the fabric is a
filament nylon cloth having a pre-processed thread count
20 of 48 x 54, 420 denier, approximate weight of 6.02, and
the finishing treatment increases the air permeability
from approximately 0.44 to 2.1 cfm/ft².

25. A uniformly finished woven fabric as claimed in
any one of claims 15 to 17, wherein the fabric is a nylon
25 filament cloth having a pre-processed thread count of 32
x 32, 840 denier, approximate weight of 7.7 oz/yd², and
the finishing treatment increases the air permeability
from approximately 3.88 to 9.31 cfm/ft².

26. Apparatus for finishing textile fabrics having filament yarns which are interlaced at cross-over points to define interstitial open areas, the apparatus comprising:

5 a conveyor for conveying the textile fabric to a fluid treatment station along a machine direction, the conveyor including a support surface for the fabric;

 a fluid means for uniformly impacting the conveyed fabric in fluid treatment station with a continuous
10 curtain of fluid comprising a plurality of densely spaced liquid jets, said liquid jets emanating from a plurality of jet orifices having a diameter of 0.0081 to 0.0229 cm (0.0032 to 0.009 inches), and centre-to-centre spacing of 0.0244 to 0.0635 cm (0.0096 to 0.025 inches),

15 wherein said continuous fluid curtain having a sufficient energy to improve the uniformity of the yarn spacing within the fabric.

 27. An apparatus according to claim 26, wherein the continuous curtain of fluid impacts the fabric with an
20 energy in the range of 1.1×10^4 - 22.9×10^6 joule/kg (.002 - 4.0 hp-hr/lb).

 28. An apparatus according to claim 27, wherein the jets are columnar.

 29. An apparatus according to claim 27, wherein the
25 jets eject divergent, fan sprays having an angle of divergence so as to provide overlapping jets of liquid.

 30. An apparatus as claimed in any one of claims 26 to 29, further comprising a pre-tenter station positioned

before the fluid treatment station for stretching the fabric to a pre-determined excess width.

31. An apparatus according to claim 30, further comprising a post-tenter station positioned after the
- 5 fluid treatment station for stretching the fabric to an output finished width.

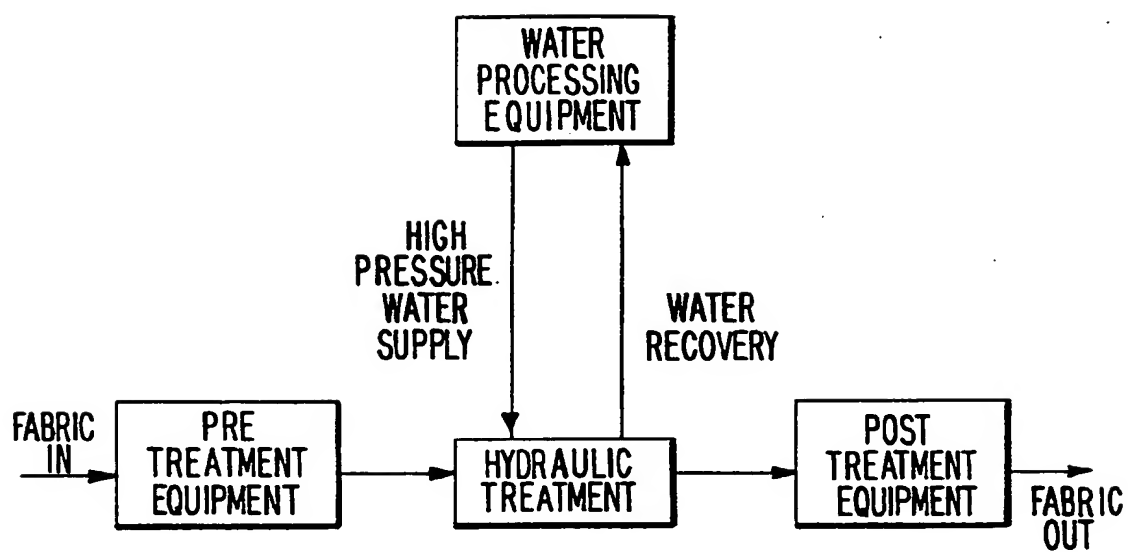
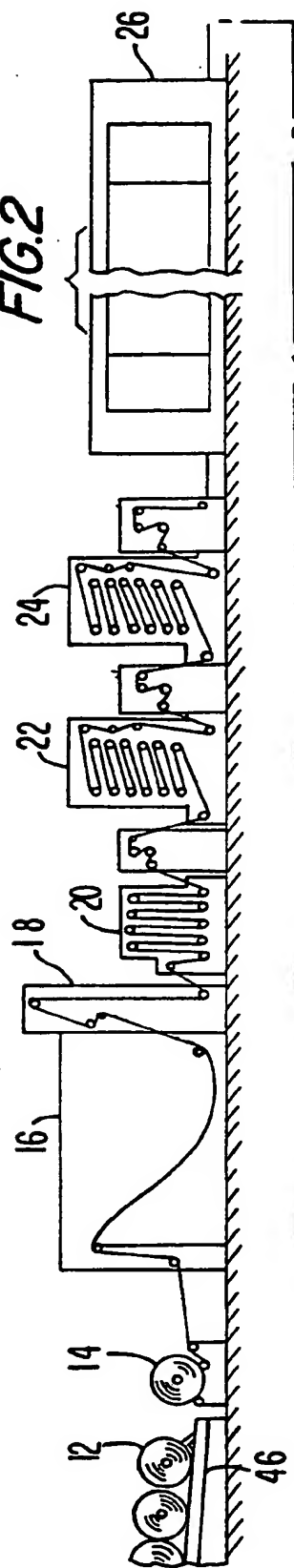
FIG. 1

FIG. 2



2/9

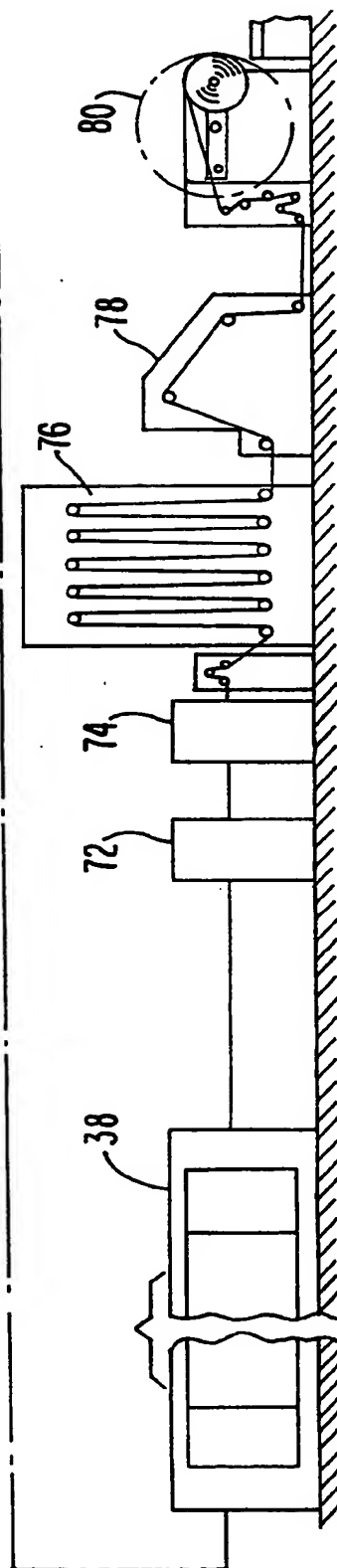
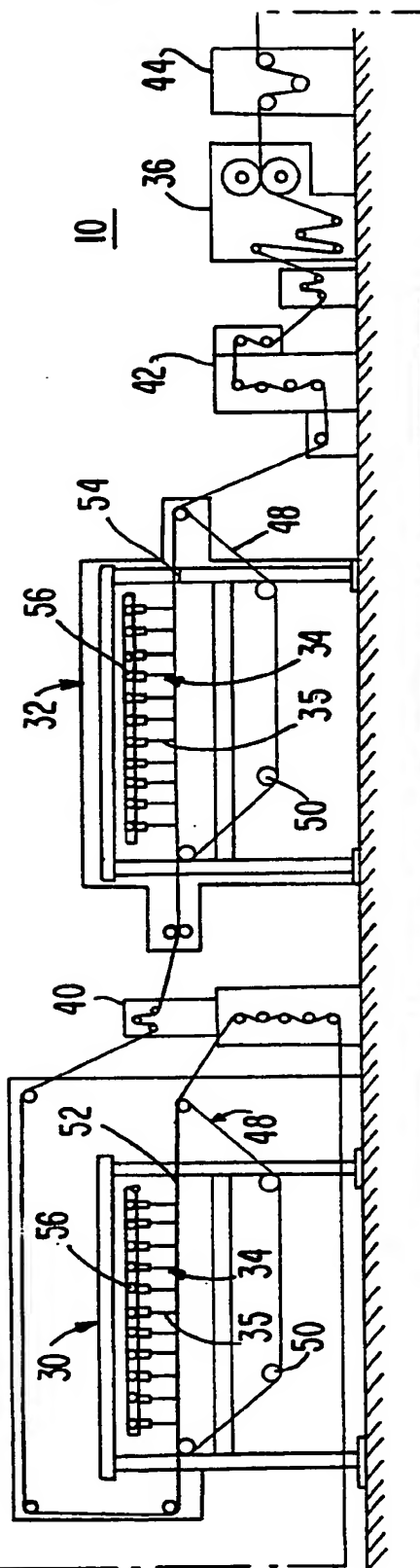
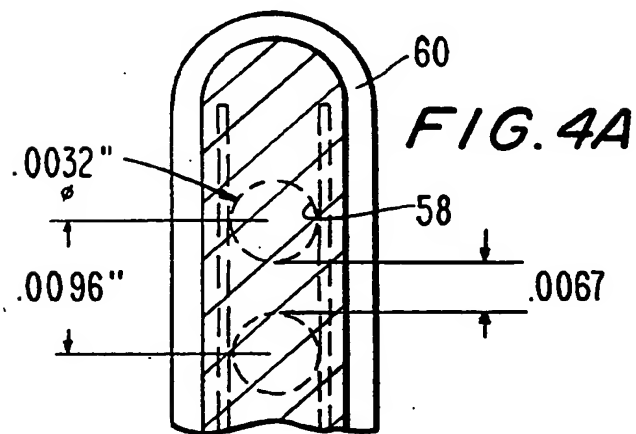
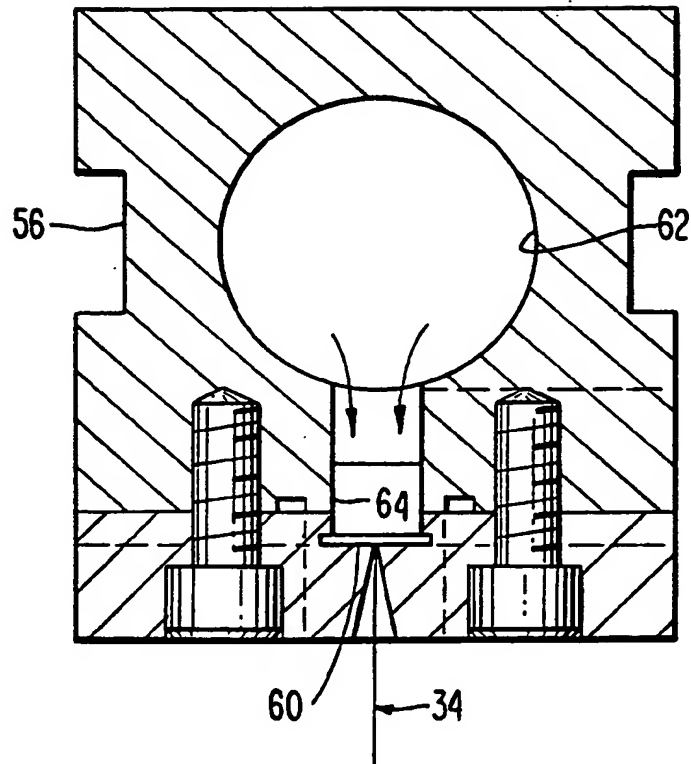


FIG. 3

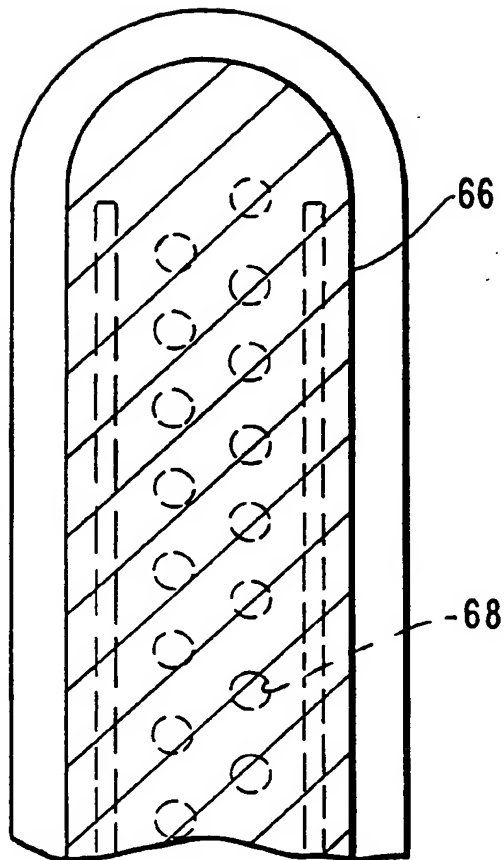
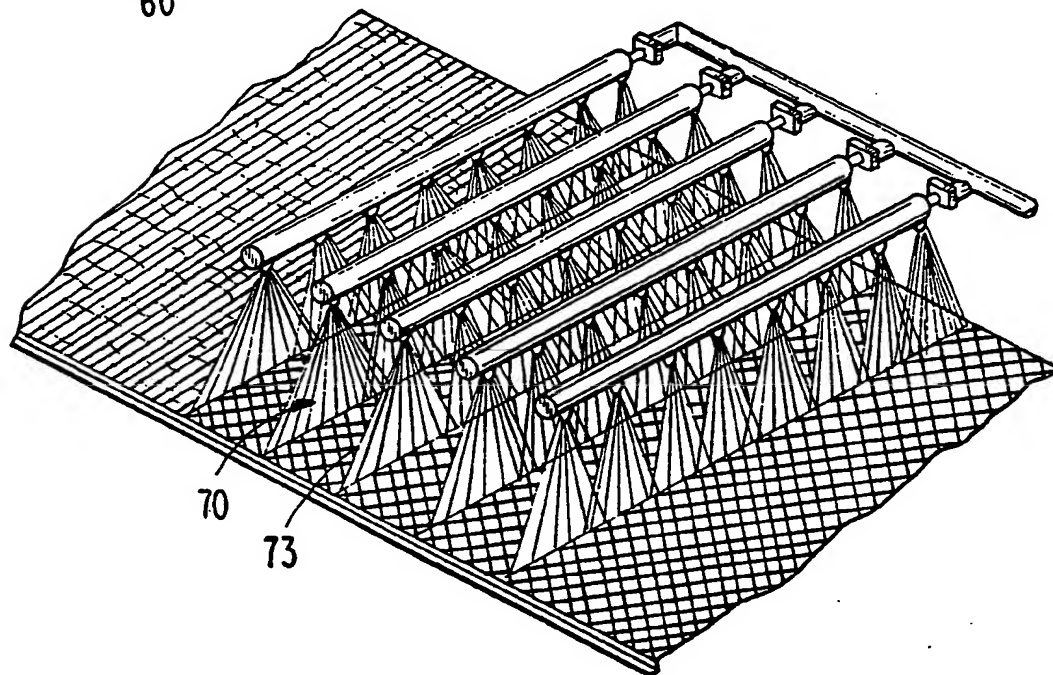
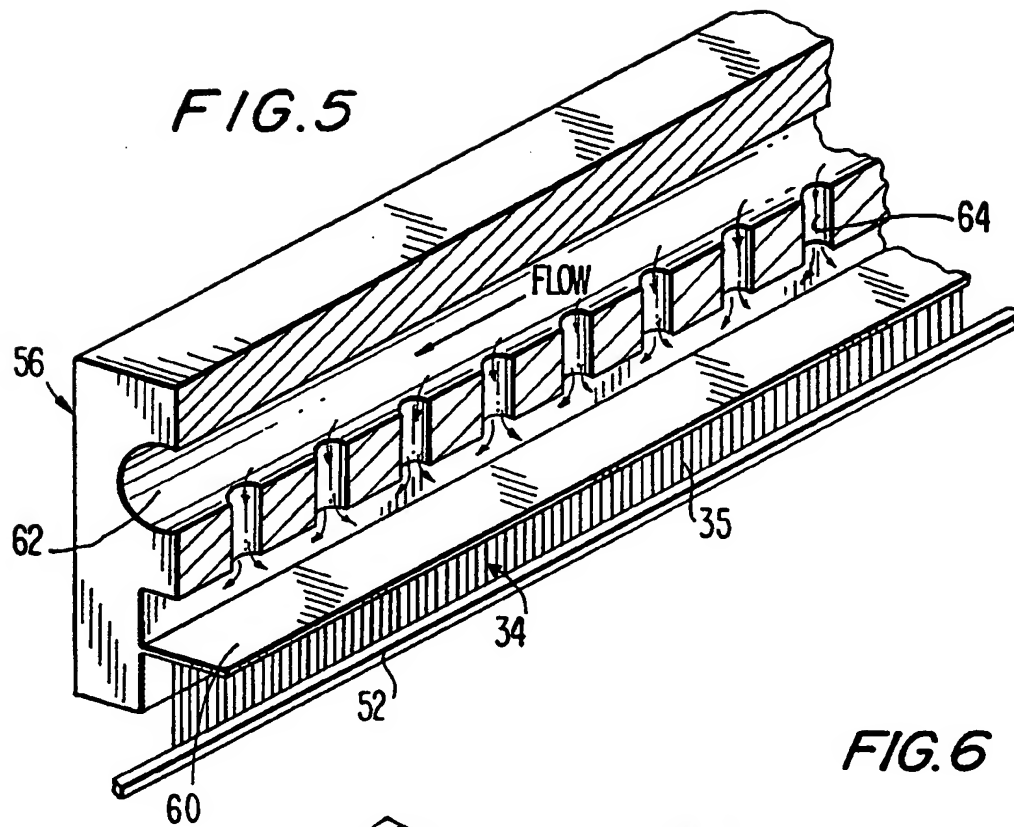


FIG. 4B



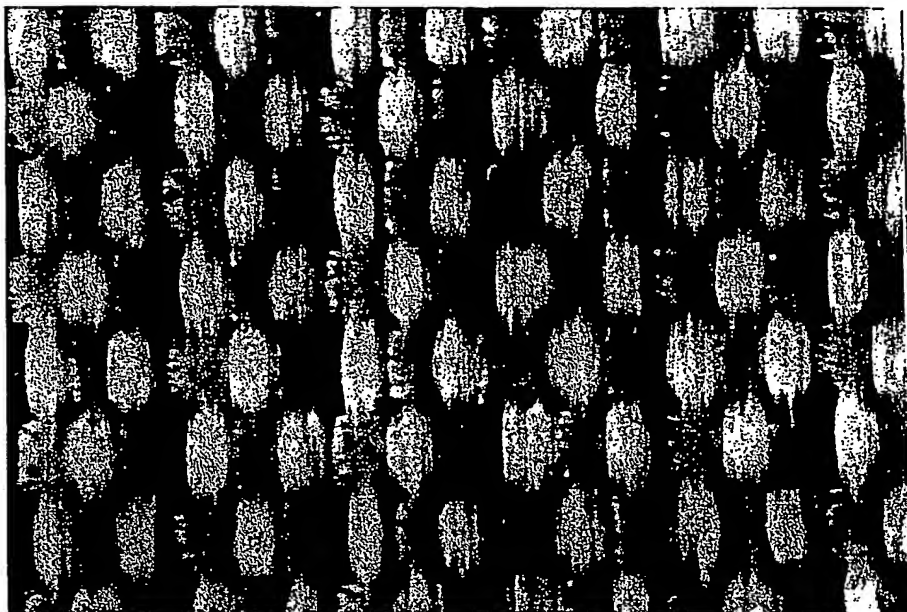


FIG. 7A

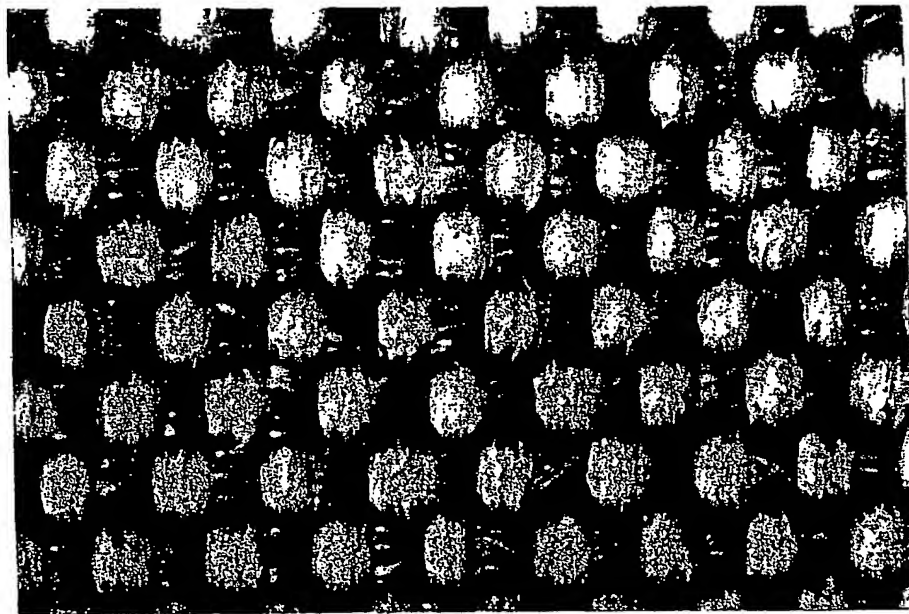


FIG. 7B

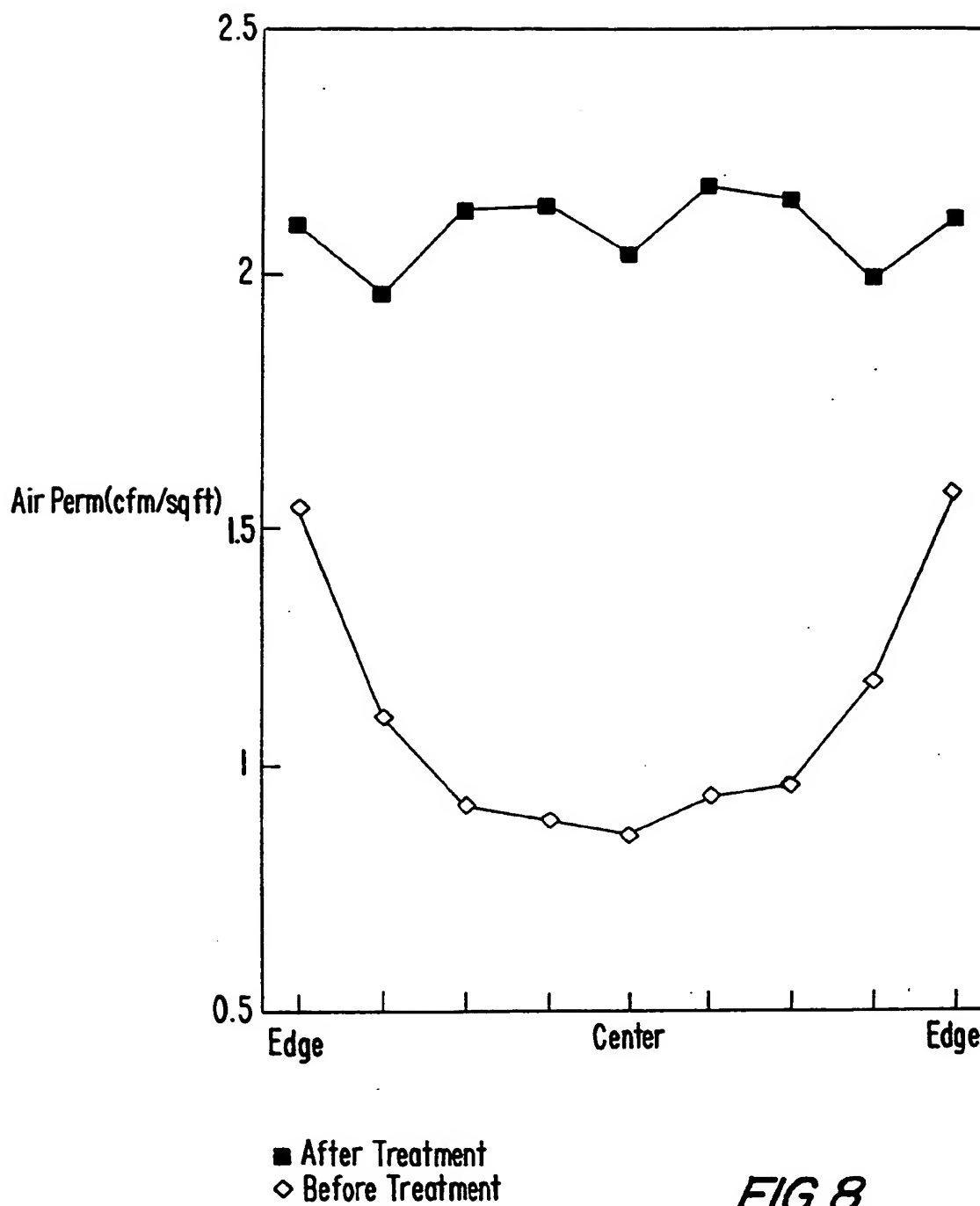
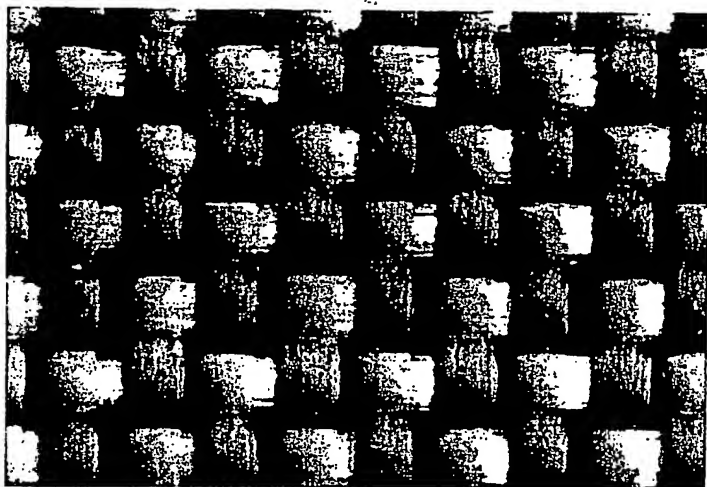
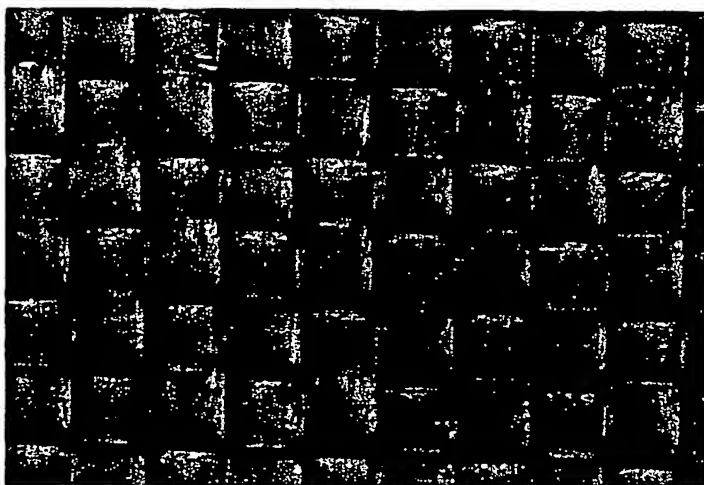


FIG. 8



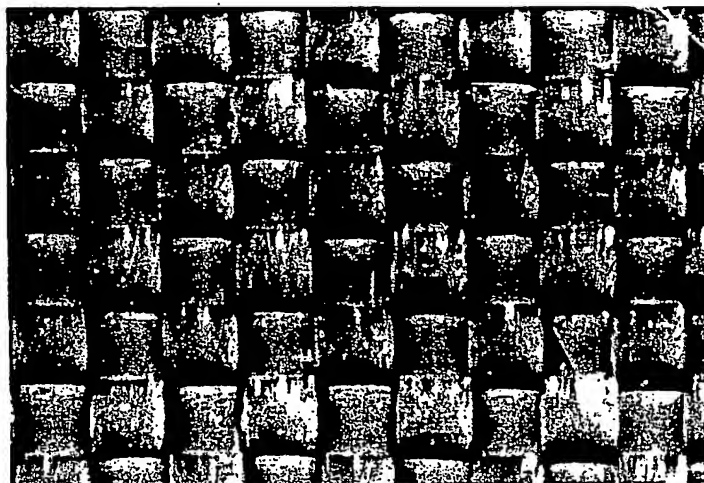
Sample A Control

FIG. 9A



20X Sample A 200 psi

FIG. 9B



Sample A 300 psi

FIG. 9C



Sample A 1500 psi

FIG. 9D

INTERNATIONAL SEARCH REPORT

 International application No.
 PCT/US/10077

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : D04H 1/46

US CL : 28/104, 167; 8/151.2, 151

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 28/104, 167; 8/151.2, 151

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 4,967,456 (STERNLIEB ET AL) 06 NOVEMBER 1990, all of columns 3-14 and Figures 1-16.	1-3, 5, 10, 11, 15-18, 20, 23, 26-31
X	US, A, 4,960,630 (GREENWAY ET AL) 02 OCTOBER 1990, all of columns 4-11 and Figures 1-9.	1-3, 6, 7, 15-17
X	US, A, 5,136,761 (STERNLIEB) 11 AUGUST 1992, all of column 7 and Figure 1.	1, 3, 10, 16, 17, 20, 26
Y	WO, A, 89/09850 (VERATEC) 19 OCTOBER 1989, page 9, lines 5-18.	1, 3, 6, 8
Y	US, A, 4,647,490 (BAILEY ET AL) 03 MARCH 1987, all of column 3.	1, 11, 12.
A	US, A, 3,449,809 (SHIN) 17 JUNE 1969, entire document.	1, 15

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:	* T	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
* A document defining the general state of the art which is not considered to be of particular relevance	* X	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
* E earlier document published on or after the international filing date	* Y	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
* L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	* &	document member of the same patent family
* O document referring to an oral disclosure, use, exhibition or other means		
* P document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

29 JULY 1996

Date of mailing of the international search report

08 AUG 1996

 Name and mailing address of the ISA/US
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Authorized officer

ANDY FALIK

Telephone No. (703) 308-1283

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/10077

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 3,485,708 (BALLOU ET AL) 23 DECEMBER 1969, entire document.	1,15
A	US, A, 3,494,821 (EVANS) 10 FEBRUARY 1970, entire document.	1,15
A	US, A, 4,190,695 (NIEDERHAUSER) 26 FEBRUARY 1980, entire document.	1,15
A	US, A, 4,995,151 (SIEGEL ET AL) 26 FEBRUARY 1991, entire document.	1,15
A	US, A, 5,023,130 (SIMPSON ET AL) 11 JUNE 1991, entire document.	1,15
A	US, A, 5,080,952 (WILLBANKS) 14 JANUARY 1992, entire document.	1,15
A	US, A, 5,142,753 (BOLLIAND ET AL) 01 SEPTEMBER 1992, entire document.	1,15
A	US, A, 5,292,573 (ADAMS, Jr. ET AL) 08 MARCH 1994, entire document.	1,15
A	US, A, 5,337,460 (COCKFIELD ET AL) 16 AUGUST 1994, entire document.	1,15
A	JP, A, 61-252339 (HISHINUMA ET AL) 10 NOVEMBER 1986, entire document.	1,15
A	GB, A, 2,047,291 (DU PONT) 26 NOVEMBER 1980, see entire document.	1,15